Theoretical substantiation of the form of working separator bodies at pre-sowing stone soil treatments

Saydilla Alikulov, *Zayniddin* Sharipov, *Asqar* Igamberdiyev*, *Erkin* Farmonov, and *Bakhodir* Khakimov

"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, 100000, Uzbekistan

Abstract. The article discusses a method for planting seeds in stony soil and a device for its implementation. It has been established that the quality of seed placement in the soil significantly depends on the quality of formation of the earthy soil layer at a depth of seed placement.
A method is proposed for planting seeds in stony soil, which includes cutting off the upper layer of stony soil with its simultaneous separation, formation of stony and fine-grained layers from it and laying them alternately on top of each other, forming grooves, laying seeds on its bottom and falling asleep seeds with soil. In contrast, the depth of cut of the upper layer of stony soil is taken equal to the sum of the depth of seeding and the maximum size of stones. To implement the method, a proposed device includes a frame, a ploughshare mounted on it, and a separating grid made of several parallel wire elements, sowing machines, disc coulters, and fenders.
The economic efficiency of the proposed technical solution is associated with maintaining the period of the emergence of seedlings and, accordingly, increasing the yield of crops, as well as increasing the productivity of sowing machines.

1 Introduction

Various agricultural crops are grown in the foothill areas. However, in these areas, the soils are clogged with stones to varying degrees, which are the main deteriorating factors in the placement of seeds, thereby reducing their yield [1-8].

A known method of embedding seeds in the soil during sowing includes forming a groove, laying the seeds on their bottom, covering them with soil, and compacting and backfilling the groove. The disadvantage of this method is that when the seeds are covered with stony soil, stones fall to the bottom of the groove and, accordingly, to the seeds and form a solid coating above them.

This phenomenon sharply reduces the quality of seed placement with soil and leads to a deterioration in the necessary conditions (temperature, water-air conditions) for plant growth [9-15].

There is a method of machine planting of seeds, including the formation of a groove with the simultaneous formation and compaction of its bottom, the placement of seeds and

*Corresponding author: asqar1959@mail.ru

their pressing to the bottom of the groove, the filling of the seeds with soil, followed by the formation of a roller above them, and the compaction of the roller. The disadvantages of this method are also the poor quality of seed placement in stony soil. In addition, a sowing section is known, including a coulter, coverer, and soil separators, which in this sowing section is the low quality of embedding seeds with stony soil, since the soil separators ensure the removal of stones that are only on the soil surface [16, 17].

Closest to the proposed is a closing device of a cotton planter, including a coulter with a clod ejector, pushing and rolling rollers, and harrows mounted on the frame, and the quality of seed embedding with stony soil is also poor.

2 Methods

The quality of seed placement in stony soil significantly depends on the quality of formation of the earthy soil layer at a depth of seed placement, i.e., from the complete exclusion of stones that adversely affect the operation of the closing organs of the seeder.

This condition is achieved by: firstly, the processing of stony soil at a depth greater than the sum of the seeding depth and the maximum size of the stones; in this case, the possibility of large stones falling into the earthy soil layer is completely excluded; secondly, due to the high-quality separation of small stones from the soil on the separator.

High-quality seeds (for example, wheat) incorporation into stony soil can be carried out from the following sequentially performed operations.

When the sowing unit moves forward, the upper layer of stony soil is cut to a depth greater than the sum of the depth of seeding and the maximum size (along the length) of stones, and at the same time, furrows are formed to a depth greater than the maximum size of stones. In this case, the protrusion of even a part of large stones into the earthy soil layer is excluded. After that, the cut layer of stony soil is directed towards the separator, while large stones, having a large weight, are separated from the stony soil layer during flight and fall to the bottom of the furrow. In the separator, small stones located inside the soil layer are separated from the fine-grained part of the soil; they form stony and earthy soil layers from them and stack them alternately on top of each other above the bottom of the furrow.

In the future, grooves will be formed on the earthy layer of soil; seeds will be laid on its bottom and covered with soil.

Thus, the formation of a fine-grained layer on the soil surface and high-quality seed placement makes it possible to obtain friendly seedlings due to the uniform placement of seeds on the bottom of the furrow, as well as to increase the productivity of sowing machines by reducing machine downtime (the number of breakdowns of working bodies from stones is reduced).

To implement this method, a stone separator is proposed that is installed at the front of the seeder (Fig. 1), including a frame 2, a ploughshare 8 installed on it, a separating grid 9, made in the form of several parallel wire elements, forming the surface of each of them is made in the form of a part ellipse, casing 10, attached to the seeder, having sowing units 4, disc coulters 6 and harrows 7. Due to the high-quality placement of seeds in stony soil by forming an earthy soil layer on the surface of the field, this device makes it possible to increase the productivity of sowing units.

The device is used for sowing seeds of various agricultural crops and improving the quality of seed placement during the pre-sowing treatment of stony soils.

The device works as follows. Before operating the sowing unit, the angle of attack of the plowshare is preliminarily set to 8 using an adjustment mechanism depending on the maximum size of the stones.

When the sowing unit moves forward, the ploughshare 8 cuts off the top layer of stony soil with the simultaneous formation of a furrow and directs it towards the wire elements 9.

Stones that have a large weight are separated from the soil layer during flight and enter the bottom of the furrow, and small stones from the earthy part of the soil on wire elements 9, while they are separated from the earthy part of the soil form a stony layer from them and are laid on the bottom of the furrow.

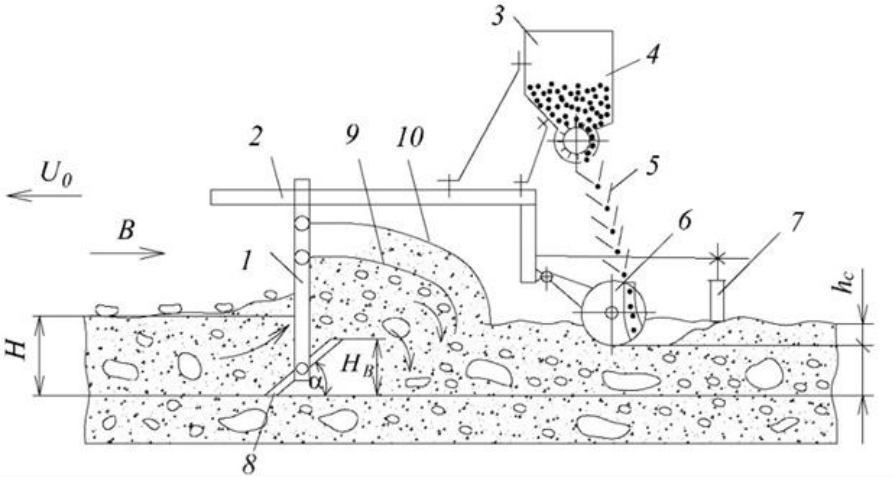

Fig. 1. Device for planting seeds in stony soil: 1 is stand, 2 is frame, 3 is bunker, 4 is sowing unit, 5 is seed tube, 6 is disc coulter, 7 is harvester, 8 is ploughshare, 9 is separating grid, 10 is casing.

The earthy part of the soil formed in the process of separation through the gaps between the separator wires with the help of casing 10 forms an earthy soil layer and is laid on a rocky soil layer. Later, on the earthy layer of soil, the seeders open the grooves with the 6 coulter; the seeds are placed on its bottom by the sowing machine 4 through the seed duct 5, and they are covered with soil with 7 seeders.

3 Results and Discussion

It has been established that the quality of seed placement in the soil significantly depends on the quality of formation of the earthy soil layer at the

depth of seed placement, i.e., from the complete exclusion of stones, which negatively affects the operation of the seeding planting organs.

Given the above, the angle of attack (α) of the separator share (Fig. 2) must be set in such a way that the depth of the groove (H_b) formed after the passage of the share must be greater than the maximum size of large stones (l_k) and is determined by the formula:

$$\alpha \geq arcsin\ \frac{l_k}{B} \qquad (1)$$

where B is the share width, m.

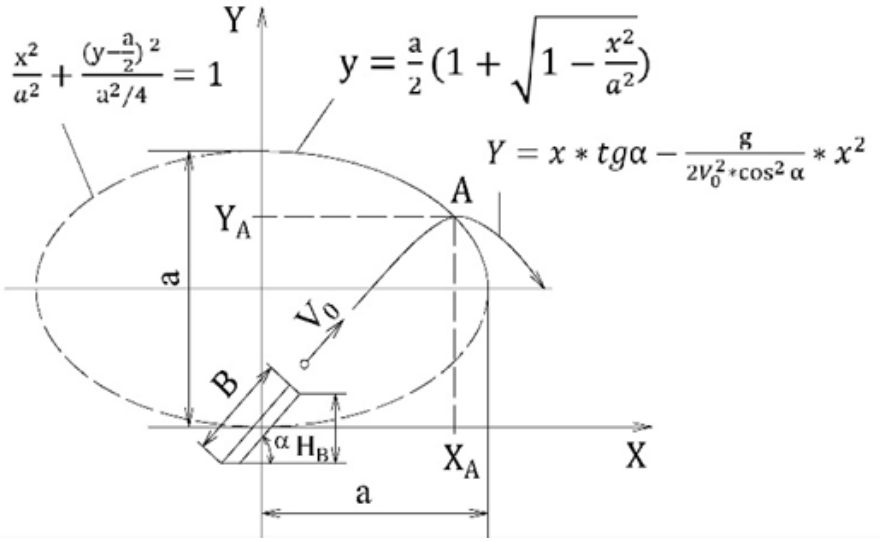

Fig. 2. Motion of a particle thrown at an angle to the horizon

It has been established that the efficiency of separating stones from the earthy part of the soil with separator wire elements depends, firstly, on the angle of attack (α) of the ploughshare (because it affects the maximum height of the soil layer), and secondly, on the location and shape of the wire elements (since it is necessary to comply with such a condition that the maximum height of the soil layer (point A) is behind the wire elements at any angle of attack of the plowshare). The trajectory of the movement of the soil layer with stones is determined by the formula

$$Y = x\,tg\alpha - \frac{g}{2V_0^2\cdot\cos^2\alpha}\cdot x^2 \qquad (2)$$

where x is the argument, m; y is a function of x; α is the angle of attack of the plowshare, deg; g are accelerations due to gravity, m/s^2; v_0 is the speed of the particle, m/s.

The coordinates of point A, depending on the angle of attack of the ploughshare, are described by the expressions:

$$\begin{cases} Y_A = \frac{v_0^2}{2g}\sin^2\alpha \\ X_A = \frac{v_0^2}{2g}\cos^2\alpha \end{cases} \qquad (3)$$

Denoting $v_0^2/2g = a$, and solving the system in the form $y = f(x)$, we get equation (4) is an ellipse with axes a and $a/2$, while the coordinates of its center are the point $[0;\ a/2]$.

$$\frac{x^2}{a^2}+\frac{(y-\frac{a}{2})^2}{a^2/4}=1 \qquad (4)$$

In this case, the most rational part of it is the part that is limited to 0≤x≤a and is described by the equation

$$y = \frac{a}{2}\left(1 + \sqrt{1 - \frac{x^2}{a^2}}\right) \qquad (5)$$

Proceeding from this, equation (6) is taken as the generatrix of the surface of the wire elements of the separator.

4 Conclusions

1. Before the seeding unit works, it preliminarily sets the angle of attack of the plowshare with the help of an adjusting mechanism, depending on the maximum size of the stones.

2. To improve the quality of seed placement, the earthy soil layer is laid over the rocky one, and the cutting depth of the upper layer of rocky soil is equal to the sum of the seed placement depth and the maximum size of the stones.

3. The stone separator grate is provided with a casing, and the resulting surface of each wire element of the grate is made in the form of a part of an ellipse described by the equation:

$$y = \frac{a}{2\left(1+\sqrt{\left(1+\frac{x^2}{x^2}\right)}\right)}; \quad 0 \le x \le a$$

where x is argument, m; y is a function of x; a is the major axis of the ellipse, m.

4. Due to the formation of a fine-grained layer on the surface of the soil and high-quality seed placement, and increase the productivity of sowing machines by reducing machine downtime (the number of breakdowns of working bodies from stones is reduced).

References

1. Djibilov S. M., Gulueva L. R. Mechanized method of removing and recycling stones on mountain slopes. Agricultural machinery and technologies, **14**(2), pp. 23-28 (2020)
2. Bartenev I. M., Pozdnyakov E. V. Wearing capacity of soils and its influence on the durability of the working bodies of soil-cultivating machines. Forestry magazine, **3**, - pp.114-123 (2013)
3. A.R.Muratov, A.U.Atazhanov, O.A.Muratov. Issues of mechanized removal of stones from irrigated lands. International scientific-practical conference "Science, education, innovations for the agro-industrial complex: state, problems and prospects". II - part, November 22-23, Tashkent (2019)
4. Igamberdiyev A., Alikulov S., Berdimuratov P., Artiqbaev B., Berdimurodov U., and Usarov O. Modern direction for agricultural development in the Republic of Uzbekistan. In IOP Conference Series: Materials Science and Engineering, 883(1), (2020)
5. Igamberdiev A. K. Substantiation of technological and design parameters of the coulter. Journal Agricultural machines and technologies. **2**, pp.15-29. Moscow, (2017)
6. Ageychik V. A. Patterns of distribution of stones in the soil. Engineering and technology: innovation and quality: international materials. Scientific and practical conference. pp. 379-382 (2007)
7. A. S. Avankina, V. V. Golubev, and A. S. Firsov, Investigation of the interaction of a combined coulter with soil. **3** (70), pp. 15–22 (2017)

8. E.I. Majugin, A.L. Kazakov. "Reclamation machines", p. 307 (2018)
9. M. Karimov, Z. Sharipov, T. Usmanov, N. Usmanov. Experimental research results on the erosion study of the temporary irrigating canal dam with pouring water and the establishment of the size of the dam compactor's operating body. In IOP Conf. Series: Earth and Environmental Science **1043**, (2022) doi:10.1088/1755-1315/1043/1/012040
10. T. Usmanov, M. Karimov, Z. Sharipov, N. Usmanov, M. Kholbutayev. Dependence of the operating body parameters of the cleaner tray to the cross-section of the pump. In IOP Conf. Series: Earth and Environmental Science **1043**, (2022) doi:10.1088/1755-1315/1043/1/012039
11. S. Alikulov, Z. Sharipov, A. Igamberdiev, E. Farmonov, B. Khakimov. Theoretical substantiation of the form of workers separator bodies at presowing stone soil treatments. IV International Scientific Conference "Construction Mechanics, Hydraulics and Water Resources Engineering" (CONMECHYDRO-2022) (2023).
12. A. Igamberdiev, E. Farmonov, S. Alikulov, G. Usmanova, Z. Sharipov. "Assessment of the physical properties of soils in Uzbekistan. IV International Scientific Conference "Construction Mechanics, Hydraulics and Water Resources Engineering" (CONMECHYDRO-2022) (2023).
13. L.Babajanov, Z.Sharipov, B. Khakimov, "Plow for processing row spacing of gardens". E3S Web of Conferences **264**, (2021) https://doi.org/10.-1051/e3-sconf/202126404040
14. B. Khakimov, N. Rajabov, Z. Sharipov, S. Kalandarova, E. Ganiboyeva. Analysis of methods of forming diesel and bioethanol fuel mixture". In IOP Conf. Series: Earth and Environmental Science **868** (2021) doi:10.1088/1755-1315/868/1/012022
15. A. Li, B. Sultanov, Z. Sharipov, N. Umirov. Modelling the process of local application of manure under glass crops. In IOP Conf. Series: Earth and Environmental Science **868** (2021) doi:10.1088/1755-1315/868/1/012008
16. A. Anarbaev, O. Tursunov, D. Kodirov, Z. Sharipov. Changes of chemical reactions in soil during electric processing by means of UV-radiation. In E3S Web of Conferences **304**, (2021) https://doi.org/10. 1051/e3sconf/20213040
17. M. Karimov, Z. Sharipov, T. Usmanov. Optimization of the dimensional parameters of the working body for compaction temporary sprinkler dams. Innovate electronic bulletin. International periodic journal of scientific works, **2**, pp.17-22 (2021)